AN INSTITUTIONAL PERSPECTIVE ON BIM IMPLEMENTATION – A CASE STUDY OF AN INTERCITY RAILWAY PROJECT IN NORWAY

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Abstract

Architecture and engineering offices around the world increasingly replace their dated Computer-Aided-Design (CAD) solutions with Building Information Modelling (BIM) solutions. There is a profound IT-enabled change in the way in which commercial and residential buildings are designed and produced. However, parts of the industry remain largely excluded from this trend, as roads and railroads continue to be designed based on two-dimensional CAD systems. This paper reports from a case study of BIM implementation in a Norwegian railroad project Based on institutional theory, we identified how institutional pressures affected the BIM implementation of the project team in the InterCity railway project. The cases study highlights the important role of the client's BIM manager in enforcing these pressures in practice. Furthermore, the paper provides useful insights not only for construction project teams seeking to implement BIM in infrastructure projects but also for other organizations adopting new technologies.
Keywords: Institutional pressure, building information modelling, infrastructure, railway.

Introduction

"*Using BIM [Building Information Modelling] as a planning tool improved our process on nearly every front. With BIM, we could reduce the environmental impact of our project, optimize designs across disciplines, and increase democracy and transparency in our planning*" BIM Manager, Bane NOR [1]

The statement above appeared on Autodesk's web page after the Norwegian "InterCity line" railroad project had been awarded the software vendor's prestigious Architecture, Engineering, and Construction Excellence Awards in 2016. The project was lauded for having succeeded in using BIM technology effectively to attain approval from more than one-hundred project stakeholders. Bane NOR, the national Norwegian railroad administration, stated that using BIM software was influential in reducing the adverse environmental impact of the railroad project, ensuring good communication with the project stakeholders, and explaining the project to the wider public. InterCity, the largest ever infrastructure construction project Norway, is positioned to become a national role model for BIM use in transportation projects.

Building Information Modelling software packages have been developed, as the name implies, for supporting the design of buildings. It is only recently that software vendors have begun offering similar solutions for transportation projects. Moreover, the processes for BIM-based work in transportation are just beginning to emerge. Thus, exploring the results of an early implementation of this new software in its industrial context affords an opportunity for understanding the implementation process. Moreover, the recent technological advancements in the architecture, engineering, and construction industry would seem to be an area in need for further information systems (IS) research [2]. There is a well-established knowledge base in IS research that can be drawn upon for studying the implementation of information systems. Moreover, the existing potential to contribute to transforming a major industry such as infrastructure construction is a worthwhile undertaking.

The motivation of this paper roots in the difficulties occurring when new technologies are implemented in a transportation project. Since McKinsey Global Institute [3] reported that the construction labour-productivity growth lagged behind that of the total economy from 1995 to 2014 worldwide, contributions to technology implementation in construction could support to solve this problem. With this notion in mind, we looked for a framework helpful for understanding technology adoption and found institutional theory, which has proven value for explaining change processes and innovation adoption [4], to be an appropriate theoretical lens for the study. Institutional theory considers the processes by which rules, schemas, norms, and routines are formed to become stable foundations for social behaviors. Institutions are routinized social behaviors that are continuously reproduced by a set of actors. Therefore, institutional theory is a worthwhile theoretical view for exploring how BIM technology use in transportation projects can be turned in to a taken-for-granted and continuously self-producing social behavior. The theory is useful for understanding what makes an IT innovation "stick" in organizational settings [4].

Understanding the institutional effects on the BIM-based work in this railroad project is a good starting point for other construction project teams seeking to implement this technology in their projects, through insights into what motivates project teams to work based on BIM. Since there are few examples in the literature reporting in depth on how to make BIM work in railroad projects, we contribute by asking the following research question: *What are the institutional effects on the BIM implementation in the InterCity line railroad project?*

To address this question, we present a case study conducted in the InterCity project, analysing how the multiple actors organized and used BIM in their project. The theoretical lens guiding the data collection is institutional theory. The intended contribution of this paper is twofold. First, we argue that research taking an institutional perspective can broaden the theoretical understanding of BIM implementation in transportation projects. Second, the practical contribution of this paper is to showcase some of the influencing factors for successfully implementing BIM in transportation projects.

Building Information Modelling: The Artifact Explained

The crucial difference between BIM and earlier non-object-based 3D CAD solutions is the concept of object-based design. BIM joins object-based design, relational databases, and parametric manipulation. Object-based design or solid modelling technology allows for the description of geometric objects in 3D space fully. Relational databases fused with the solid objects allow for linking building product specifications to the objects represented in the model. Parametric change engines make the objects "smart" by enabling their automated modification. In other words, "Doors will fit automatically into a wall [and] a light switch will automatically locate next to the proper side of the door" [5]. In essence, the software allows for creating virtual prototypes or so-called "digital twins" of buildings and/or infrastructure. Moreover, BIM serves as a design space where multiple organizations engage in collaborative dialogue [6, 7].

Rapid advances in building information modelling offer new opportunities for improving processes in the architecture, engineering and construction industry. BIM aids project teams to cut costs, achieve higher productivity, accuracy, better communication, and efficiency [8]. However, Cheng, Lu [9] point out that there is a tendency for construction practitioners to think that BIM's benefits are limited to building construction projects. In fact, there is a belief in some quarters that transportation projects differ substantially from buildings and that BIM technology would not yet yield benefits for these types of projects (ibid.). While BIM has become widely diffused in building construction, transportation is left behind. Transportation projects include bridges, roads, railways, tunnels, ports and harbors [9].

Arguably, there are several differences between building and transportation projects having to do with their structural components. Moreover, they are executed by different communities of practice whose technical language differs considerably. For instance, a column in a building is equivalent to a pier in a bridge. Furthermore, railroads, roads, and bridges have their components arranged horizontally based on central or reference lines. This is why BIM for infrastructure is frequently referred to as "horizontal BIM" whereas BIM in building construction is referred to as "vertical BIM" [8]. Thus, the logic on which infrastructure projects are based is almost the diametrical opposite to that of generally vertical building design [10]. In the US the implementation of BIM technology in infrastructure projects is about three years behind BIM implementation in building projects [8].

Theoretical lens

We adopt institutional theory to identify and understand what helped the InterCity project team succeed in their implementation of BIM technology. There is a legacy of IS studies using institutional theory to identify the driving forces behind technology implementation in organizations. To illustrate this, a recent review of the literature identified 53 articles published in 20 IS outlets using institutional theory in the period from 1989 to 2009 alone [11]. In fact, institutional theory has been used to study innovations in organizational settings since the end of the 1970s [12, 13]. These types of studies focus both the institutional effects and institutionalization of innovations [11]. Institutionalization is about different formation stages of institutions. Institutional effects refer to the influences of an institution on other institutions, organizations, or organizational entities (ibid.).

Table 1. Three pillars of institutions [12]

	Regulative	**Normative**	**Cultural - cognitive**
Basis of compliance	Expedience	Social obligation	Taken for granted
Mechanism	Coercive	Normative	Mimetic
Logic	Instrumentality	Appropriateness	Orthodoxy
Indicators	Rules, laws, sanctions	Certification, accreditation	Prevalence, isomorphism
Basis of legitimacy	Legally sanctioned	Morally governed	Culturally supported, conceptually correct

The theory is also a powerful tool to explain individual and organizational behaviors in technology adoption [14]. According to Dimaggio and Powell [15], an organizational field includes "those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services and products". The concept of organization field allows institutionalists to craft relationships between a given organization and its environment [12]. In these relationships, organizations desire for legitimacy for not only survival but also social acceptability and credibility in their environment in the long run. Therefore, organizations will strive for legitimacy, and their behaviors are controlled and constrained by institutions. Scott [12] suggests that "institutions comprise regulative, normative and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life". Regulative, normative, and cultural-cognitive pressures result in social structure either imposed on or upheld by organizations and individuals. These social structures are then translated into 'scripted' organizational and/or individual behavior which on the long run may become taken for granted and institutionalized [12]. In short, organizations follow institutions to achieve legitimacy [11]. Legitimacy is defined as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" [12]. Institutional theory has proven its value in IS research and scholars have shown how institutional effects work on distinct phases of the IT/IS implementation process, identified response strategies to institutional pressures, and explained the interaction between IT artifacts and institutions [11]. However, institutional theory is not without criticism and it has been argued that it fails to adequately theorize differences across organizations [13].

As can be seen in Table 1, institutions are formed by three pillars, namely regulative, normative, and cultural-cognitive pressures. The three pillars form or support institutions in different dimensions and could be used as an analytic framework to understand institutions. The regulative pillar contains regulatory or rule-setting activities by institutions [16]. In effect, this pillar gives prominence to explicit regulatory processes such as rule-setting, monitoring, and sanctioning activities (ibid.). Normative systems "define goals or objectives (e.g., winning the game, or making a profit), but also designate the appropriate ways to pursue them" [16]. Values or norms may be applicable to all or at least several members of a collective (ibid.). In plain English, this pillar is about following guidelines imposing constraints on social behaviour. Cultural–cognitive systems are more about constructing a common meaning in the collective. This dimension is not so much about the objective conditions in a social environment, but the actor's subjective interpretation of them (ibid.). Moreover, this pillar is concerned with cultural aspects, symbolic aspects of social life, and belief systems that exist in a collective (ibid.). A good example of how such meanings are formed are isomorphic mimetic pressures [15].

In construction projects, the project team performs its tasks in a relationship with other organizations such as clients, administrative agencies, contractors, consultants and other similar project teams. This leads us to argue that institutional theory could be a suitable lens to understand a project team's behaviors, which in the case of this paper is the implementation of BIM as an information system [14, 17]. Understanding the change from traditional drawing to model-based design is important to explain the BIM implementation process. Understanding change might also reveal "how things stick" [4], i.e. how to retain innovation in the organization. More explicitly, this paper utilizes institutional theory to explore the mechanisms that shape BIM implementation in the case study. We use the three pillars of institutions as depicted in Table 1 to inform the analysis part of this paper.

Methodology

The setting of our case study is the 270 km InterCity railroad project including 25 new stations connecting the cities of Oslo, Lillehammer, Halden, Porsgrunn and Hønefoss in eastern Norway. We collected our data during the design stages of the Dovrebanen line, a 75-km double track railway from Sørli to Lillehammer in the second quarter of 2017. This part of the project has been chosen based on several selection criteria. The first criterion was that the project participants should resemble a rather typical constellation of actors involved in the design of railway projects to ensure that we would capture how institutional pressures influence their BIM-based work. The second criterion was to choose a project where digital modelling technology was used in the project design stage. The third criterion was that we needed a railroad project where BIM had been implemented with some success. The Dovrebanen project fulfilled this criterion since the project team won the Autodesk 2016 AEC Excellence Awards, recognizing their successful BIM application. The project benefited from BIM usage when determining the characteristics of the physical alignment of the railroad. BIM was influential for integrating existing railroad tracks, harmonizing crossings with existing main streets, and protecting valuable landscapes from adverse environmental impacts. Furthermore, BIM was used as a medium to facilitate communication across the 120 internal and external stakeholders of the project [1].

For capturing how BIM-related practices were adopted by the organizations participating in this project and how and why individuals conformed to the new practices, we informed the data collection by institutional theory. More precisely we structured our interview guides based on the three institutional pressures as suggested by Scott [16] namely: regulative, normative and cultural cognitive (ref. Table 1). The questions posed to the individuals participating in our study aimed to reveal the activities (experience sharing, learning…), the materials (standard, certificate, model…) and information sources related to BIM in the experience of the project members. The interviewees went through seventeen open questions to tell their stories about BIM implementation in the project. At the end of each interview, the interviewees were asked to rank the reasons for BIM implementation. We expect to find causes that are outside of the institutional theory framework.

Fig. 1. Screenshot from the Dovrebanen BIM model (© 2017 Helga Nes, RIFs årsmøte, BaneNOR)

The data collection started in February 2017 by sending the letter of intent to the project director. After the administrative procedure, the first interview with the project's BIM manager took place in the end of March. Based on the background collected from this interview, we met members who hold managerial or coordinating positions for getting in-depth data on the BIM implementation process. From May to June 2017, a total of ten interviews were conducted and recorded. This included five informants from the client team and five from the consultant team, as profiled in Table 2. These actors were in charge of coordinating the BIM work in a design team comprising two hundred consultants and engineers.

Table 2. Overview of interviewees, their disciplines, and years of experience

Client organization			**Consultancy**		
Role	Discipline	Exp.	Role	Discipline	Exp.
BIM manager	Management	20 +	Project director	Management	10-15
Project manager 1	Management	20	BIM coordinator 1	Management	15-20
Project manager 2	Management	15 - 20	BIM coordinator 2	Management	10-15
Project planner 1	Planning	20 +	BIM coordinator 3	Management	5-10
Project planner 2	Planning	15 - 20	Discipline leader	Geology	20 +

The recordings were transcribed, and coded through the use of NVivo 11. The ideas were classified into nodes that belong to the background, regulative, normative and cultural-cognitive categories. We analyzed related ideas in each node to understand the institutional effects on the project team members in BIM implementation.

Findings

This section provides our analysis based on Scott's pillars of institutions as related to the BIM implementation in the case study. First, a brief overview of the collaborative design space as established in the case project is presented, followed by a presentation of our findings structured according to the three pillars, namely (1) regulative, (2) normative, and (3) cultural-cognitive. Thereafter, this chapter presents the interviewees' perceptions of which institutional pressures they found most influential for their digital work.

The collaborative design space

Right from the start, BaneNOR (the client) decided that the entire project should be modelled based on three-dimensional design technology. At the time, BaneNOR worked on developing a national BIM modelling handbook for infrastructure projects. This work was largely based on earlier handbooks for building construction projects prepared by Norway's governmental property developer Statsbygg. The project team found these guidelines to be too generic for use in the InterCity project. This is when BaneNOR, in collaboration with a reference group involving the project consultants, began developing project specific guidelines called "3D agreement". The "3D agreement" was intended to serve as a basis for the digital collaboration. It specified how to model, what to model and the level of detail that can be expected of the individual design contributions made to the model.

The client's BIM manager took a central role in developing the guidelines. She began by preparing the initial agreement, defined the filename format, the layers and colour codes to be used in modelling, and the level of detail that should be provided by each of the disciplines throughout the different phases of the design process. The reference group then added further detail based on their experience from earlier project work and new experiences made in the InterCity project. The client, who positioned InterCity as a partnering project, demanded close collaboration of the individual consultancies.

Regulative pillar

"Force, sanctions, and expedient responses are central ingredients of the regulatory pillar" (p.61) [12] these usually come in the form of rules and laws [16]. The institutional mechanism behind the regulative pillar is coercive pressure or the "formal and informal pressures exerted on organizations by other organizations upon which they are dependent and by cultural expectations in the society within which organizations function" [15]. Thus, the actors exercising these pressures are usually governments, regulatory bodies, large organizations, and industry associations [18]. In the context of a construction project, coercive pressure could, for example, be exerted by a client's organization downwards through the supply chain.

The contracts between BaneNOR and the engineering consultancies stated that BIM and 3D modelling was to be applied in the design of the project. By demanding the delivery of 3D models, the client exerted coercive pressure on the project team affecting the engineering consultancies' behaviours. Moreover, documents attached to the contract, i.e. "Bane NOR's infrastructure BIM handbook" and an early version of the "3D agreement", specified in depth how modelling technology was to be deployed in the InterCity project. These specific guidelines may also be viewed as coercive pressures. These pressures were however rendered weak since the specifications had not been tried out in the practical setting of a railroad project before, making their application and enforcement difficult. Nonetheless, all consultancies agreed to collaborate to help the client's organization to further develop these guidelines, which may be seen as results of coercive pressure.

Bane NOR's top management stated that BIM should be used in the InterCity project. This can be viewed as a form of coercive pressure working within the client's organization itself. Thus, the client's project managers had no choice but to enforce a BIM strategy in their project. Top management, however, was not very specific and, apart from demanding BIM to be used, the client's project management team felt that there was little active support by management: "*It was a management decision that we should use a BIM model but actually there was no more support than* *that*" (BIM manager, client). Consequently, several members of the client's project team had neither prior experience nor the computer systems required for active participation in the modelling in place. Thus, taken together, this coercive pressure can be viewed as somewhat weak.

Demanding BIM or 3D modelling technology to be used in the project, in conjunction with little related experience by many of the client's engineers, left some of the consultants puzzled: "*If our client doesn't require BIM use, we will not do it*" (BIM coordinator 2, consultant). Nonetheless, there were other voices stating that they would use modelling technology even in total absence of coercive pressures: "*I will still try to use 3D modelling but maybe some of the disciplines would not be so enthusiastic because they see it just as more work, stating that they don't have the resources for doing it*" (BIM coordinator 1, consultant). A general perception was that coercive pressures exerted by the client were important for initiating modelling activity by all parties: "*The projects where it is easy to implement BIM are those where the owner demands the use of BIM*" (BIM coordinator 1, consultant).

Beyond the aforementioned, we found no instances of regulative coercive pressures related to digital modelling in the project. This is also indicated by the client's BIM manager who stated that she could "*work quite freely*". Moreover, one of client's engineers stated that his management did not really display an interest in modelling activity: "*My manager, he doesn't use 3D and he never has a question about 3D*" (project manager 1, client). Overall, the consultants viewed the coercive pressures for using 3D modelling exerted by the client's organisation as rather weak: "*The demands from Bane NOR to the consultancies* [related to 3D modelling] *were not very high*" (Project manager 1, client). This same consultant stated, however, that this situation changed dramatically once the client's organization employed a senior BIM manager with twenty years of related experience. This indicates that a client organization's coercive pressures related to BIM and 3D modelling work only become effective by a combination of having rules in place and the right people to enforce them.

There were other coercive pressures affecting digital modelling work in the project. More specifically, the municipalities' approval processes still require 2D paper drawing sets to be delivered as a basis for decision-making. This meant that while the client's management team demanded from the consultancies to use 3D modelling to create their designs, there were demands to deliver 2D drawing packages at the same time. Thus, the coercive pressures working on both the consultants and client's design team can be viewed as somewhat ambiguous and counteracting each other. Unless municipal rules are changed towards allowing for 3D designs to be used as a basis for municipal approval processes, these mixed coercive pressures will continue to exist. According to one of the client's project managers, BIM is still quite new, and: "*Many people here are using paper and they will continue using paper*" (project manager 1, client).

Normative pillar

Normative pressures primarily derive from professionalization, which is "the collective struggle of members of an occupation to define the conditions and methods of their work" [15]. Professionalization can happen through formal education and professional improvement. While education from universities and training institutions has an important role in developing organizational norms internally, associations contribute to defining professional rules and behaviours through inter-organizational networks [15]. Therefore, the educational background, trainings, professional association activities, modelling standards and certificates were the foci of the section presented here. The normative section further focused on common practices or standards that can be applied to all projects, and the sources of information.

Some of the project team members attend conferences or industry workshops quite frequently to keep abreast of recent developments in the industry. It was quite common for the engineering consultants to attend conferences and even present their work in these. The consultants stated that they attended BIM and 3D modelling specific events such as national buildingSMART events, events hosted by Norway's BIM network or events held by software vendors such as Novapoint who develop modelling software for infrastructure projects. The client's BIM manager and one of the project managers both attended similar conferences. In addition to the industry-focused conferences, the client's representatives attended BIM workshops for governmental and state institutions such as the "Nordic BIM collaboration". Attending such conferences and workshops provided the project team with updated knowledge on BIM technology use and available systems. Moreover, this indicates that there appears indeed to be quite an active "collective struggle of members of an occupation" [15] to move towards 3D modelling and BIM in Norway.

There appear to be considerable normative pressures working on Norwegian engineers to begin using 3D digital modelling systems. The project team's activity in this direction indicates that this is taken seriously by all parts of the project organization. To illustrate this, one of the consultants' BIM coordinators stated, "*It's important mainly to keep up with what other people are doing and… being visible in the market...to sell our services*" (BIM coordinator 1, consultant). Not updating oneself on the recent developments could even mean exclusion from the occupation altogether: "*You won't get a job if you cannot use a 3D model*" (BIM coordinator 1, consultant). How powerful this normative pressure is and how not adhering to it could even weaken the market position of firms follows from this quote: "*If [company] didn't want to use BIM, I wouldn't want to work there because this would tell me very much [about the employer]*" (Project planner 2, client).

Professional and social networking activities appear to be another source of normative pressure working on the engineers. The interviewees take both active and passive roles in network activities. The passive access happens through surfing social network newsfeeds on the way to work or registering the email lists for webinar invitations, reports and so on. The active approach includes googling for certain problems and following discussions on BIM related communities. Also, this form of normative pressure pushes project members to study or take training related to BIM because "*I have to be on the top of the skill level all the time*", as stated by a BIM coordinator 1. This BIM coordinator often takes courses on Lynda.com when he wants to update his knowledge. In addition, the project members perceive BIM and 3D modelling training as important formal education, while certificates related to BIM are considered less important. In their opinion, such certificates are good "*for polishing your CV, but no one cares*".

Cultural - cognitive pillar

When organizations strive for ambitious goals, they tend to imitate other organizations to replicate their perceived effectiveness. This mimicking might happen unintentionally through employee transfer or formally through industry associations [15]. Moreover, Gholami, Sulaiman [19] suggest that envy of the success of competitors, suppliers, and customers could motivate mimetic behaviours. In the case study, a precise and detailed description of how to build the 3D model in a railroad project did not yet exist. The project team thus needed to consider mimicking available 3D knowledge from elsewhere, such as existing modelling handbooks from building projects.

The client's BIM manager started up the "3D agreement" initiative. She had the idea from a friend who worked with 3D modelling in another railway project. In that project, each discipline had an agreement document to define what and how to create the objects. Thus, this makes the use of the 3D agreement in the InterCity project a case of mimicking. This indicates that cultural cognitive pressures played a role in motivating the BIM-based work in the project, too. Moreover, there is evidence for mutual learning about BIM across the different project teams working on the four lines of the InterCity project. It is, however, true that the possibilities for learning from others were limited to the team, or as the client's project manager put it: "*We don't have many projects to relate or to look to because this project is so large in scale that this has not been done before based on a 3D model*".

How the team learned from others and from available knowledge within the team is maybe best illustrated by how the "3D agreement" evolved. First, it was written based on prior industrial experiences from the project team members. In fact, some project team members had extensive BIM experience from road projects. One example is the client's BIM manager having more than twenty years of experience from consultancy work and from working at a software developer making systems for infrastructure BIM. She was familiar with most of the commercially available BIM software solutions, and also taught design courses for some years. Similarly, one of the client's project managers had worked in road projects with 3D deliverables starting as early as 2003. The consultants had quite many experienced 3D designers specialized on road projects. Thus, while railroad BIM is totally new, there exists a knowledge base in road construction that can be drawn upon: "*We did not start from zero when we established the project*" (Project director, consultant).

Similarly, mutual learning across the InterCity project organization was influential for developing the "3D agreement". A reference group of BIM experts working on the different lines was formed to inform the development of the agreement. This coordination process required the consultants to share their expertise and experience. The project team identified good practice from other projects to mimic this in their project, with some modifications. The project director stated that "*a lot of people are asking for information and I will share it*" and "*if we see useful information …then we want to apply it as soon as possible*". He also stated that the key to this learning is cooperation: "*We are working with the others but maybe not as close as we would like to, we could have been working even closer*".

Moreover, from their experience and professional network participation, most of the interviewees have the feeling that BIM is an irreversible trend in the construction industry. They "*take it for granted*" that "*there is no way back*" to the traditional design with drawings, and that "*everybody is going to work based on the new 3D modelling programs*" in the future to come.

Priority of institutional pressures

At the end of each interview, the project members were asked to rank the following three different reasons for using BIM in this project: the request from the client, good practice from other projects, and the recent trends in the construction industry. This question also opened to other reasons from the interviewees. The answers revealed that the request from the client is not always the most important reason to apply BIM. Most of the interviewees agreed that they apply BIM because they find it useful for their work; they experience the benefits from other projects, and would like to replicate this in the case study (cultural-cognitive pressures). Some interviewees were somewhat passionate about discussing benefits of BIM. Second came that they viewed BIM to be an important trend in the construction industry (also cultural cognitive pressures)

Discussion

This paper has described how institutional pressures influence BIM implementation in the InterCity project. The analysis reveals that the project members have been exposed to all three institutional pressures, jointly influencing the implementation in different ways. An overview of the pressures is presented in Table 3. The contracts with the consultant expressed coercive pressure by requesting 3D model delivery. The contract terms provided a solid reason to apply 3D modelling, but the level of detail for the model was unavailable. Moreover, the client had initially no people with the necessary expertise to follow the contract before they hired the BIM manager. We found that the degree to which the client can influence BIM practices in projects depends on a combination of top management support, contracts and rules, and the degree of BIM expertise present in the client's organization. We found also coercive pressures exerted by the municipalities counteracting digital modelling work. Based on this we suggest for policy makers to revisit municipal approval practices and allow for delivery of digital models as opposed to 2D paper drawings.

Some of the normative pressures working on all members in the project team follow from participating in professional and social networks. There seems to exist considerable peer pressure in the Norwegian professional communities towards working based on digital modelling. The practitioners felt that BIM and 3D modelling are irreversible trends. While the project team found the reason and motivation for BIM implementation from coercive (regulative) and normative pressures, the detail of the BIM implementation is rooted in mimetic (cultural-cognitive) pressures. Therefore, we would argue that early adopters of BIM in infrastructure projects are unable to specify documents for BIM implementation without extensive experience sharing with other project teams. How experience sharing supports BIM implementation might be a promising research topic.

Within the infrastructure domain, inter-project coordination seems important for BIM implementation. This was similarly found in a recent Swedish BIM implementation study [20]. This indicates that mimetic pressures are of crucial importance for succeeding with infrastructure BIM projects. Reference groups appear to act as catalysts for mimetic pressures and seem influential for project teams seeking to work based on BIM. Our findings indicate that inter-project coordination is an important channel for experience sharing among construction practitioners. The important role of mimetic pressures as drivers for BIM implementations has been identified in earlier work [21-23]. In our view, there is a need for further work in this area to explore how experience sharing, as one type of mimetic pressure, can support BIM implementations.

Table 3. Overview of the findings classified based on the pillars of institutions

Regulative pillar	Normative pillar	Cultural – cognitive pillar
• Top management demand • Modelling contracts • Modelling rules • Champions enforcing the rules • Counteracting pressures from municipalities	• Modelling skills give “professional status” • Workshop participation and membership in professional communities • Modelling prominent in social and professional networks	• Mimicking others • Inter-project reference group

Some published surveys provide insights into the reasons for BIM implementation in different countries. In Hong Kong [22] and China [24], coercive pressures from the clients and government authorities are named as the major reasons for BIM implementations. However, none of these studies actually point to pre-existing coercive pressures working in the opposite direction of BIM-based work by enforcing 2D paper drawings instead. We argue that the balance of these two diametrically opposed coercive pressures is an interesting topic for further research.

Also, our findings would seem to confirm the importance of a client’s demand for digital work. However, similar to the recent Swedish study we find that client project managers act as change agents or champions for ensuring the use of BIM within their projects [20]. Based on our findings we would argue that coercive pressures only materialize when clients have BIM champions enforcing them. Bosch-Sijtsema, Isaksson [21] argue in a similar vein and state that solid BIM knowledge is a necessary precondition for clients to be able to enforce BIM in their projects. Cao, Li [24] found normative pressures not to influence on BIM implementation. Based on our findings we beg to differ and argue that in fact, informal, normative pressures originating in individual engineers’ social and professional networks would seem crucially important for successful 3D/BIM implementation in infrastructure projects.

The above discussion is a good example of how institutional pressures begin to play out in BIM implementations. In the IS discipline, response strategies to institutional pressures have been a research area for many years [11]. We argue that exploring how construction organizations respond to institutional effects and pressures in BIM implementations is a promising topic also worthwhile for IS scholars. Considering that IS provides a strong knowledge base that can be drawn upon for studying how these new types of artifacts may influence an important industry, we argue that we need more IS work in this area.

The practical contributions of our work are that we present some of the underlying institutional pressures that made the BIM implementation in this railroad project possible. These pressures are listed in Table 3. We argue that some of these pressures are transferable to other projects and countries. However, the national Norwegian industrial context here represents a limitation to transferability. We argue that especially the normative and cultural-cognitive pressures would be difficult to replicate in other countries. The normative pressures resulting in engineers believing that their professional future hinges on their modelling skills seem to be a result of Norway having a tight-knit infrastructure BIM community mutually enforcing these beliefs: "*The infrastructure BIM community in Norway is quite small, so we all know each other*" (BIM manager, client). Moreover, within the BIM community there seems to exist a culture where knowledge is freely and openly shared between and across companies and projects.

The theoretical contribution of our work is that we provide an initial understanding of the institutional pressures influencing BIM implementations within the industrial context of railroad projects. One intriguing finding is that there exist regulative pressures working diametrically opposed in railroad projects. Moreover, we found a hierarchy of institutional pressures. The interviewees informed the importance of cultural-cognitive, normative, and regulative pressures, in that order. We would argue for more studies in the hierarchy of institutional pressures to broaden the understanding of institutional theory. The case study also reveals close-knit professional communities represent "breeding grounds" for mimetic pressures would also seem to be an interesting theoretical finding. This would represent an interesting area in need for further research.

A clear limitation of our work is that our findings are influenced by the national Norwegian context, as argued above. Moreover, all the interviewees performed managerial tasks. This helps to understand the managerial aspects of the collaboration processes that were focused in this paper. However, the voices from technicians were absent, which might leave a part of BIM implementation uncovered. Notwithstanding these limitations, this paper does illustrate the institutional effects on BIM implementation in a railway project.

Conclusion

This paper identified how institutional pressures affected the BIM implementation of the project team in the InterCity railway project. Regulative pressures stem from top management, construction contracts, modelling rules, and municipalities. The client's BIM manager is important to enforce them in practice. Normative pressures include modelling as professional status, workshops, and social and professional networks. Cultural cognitive pressures include mimicking and inter-project reference groups. Further promoting successful BIM diffusion in railroad projects would require all three institutional pressures to be in place. This paper also provides insights on technology implementation that could be transferable not only to other projects, but also to other countries. From the theoretical view, the InterCity case study indicates a hierarchy of institutional pressure, which might be an interesting topic for further studies. Moreover, this paper suggests exploring the role of professional communities in technology implementation.

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